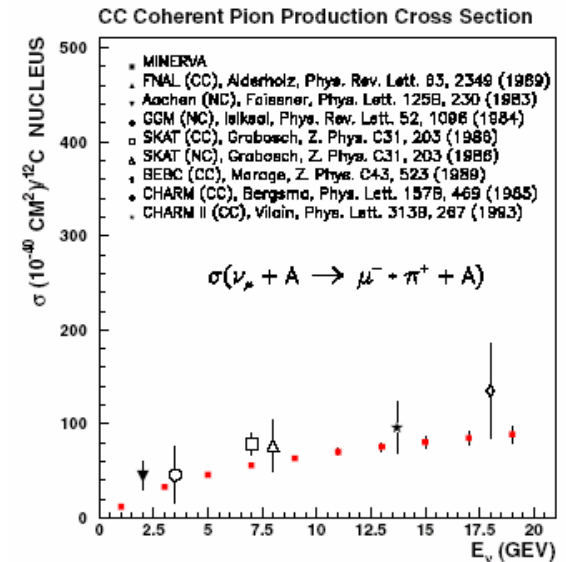


# MINERvA (E-938)

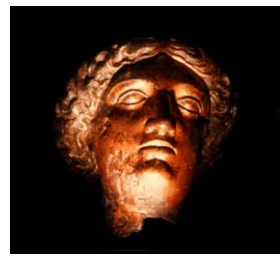
## Goals, Progress and Project

Deborah Harris  
Fermilab  
DOE Site Visit  
25 May 2005



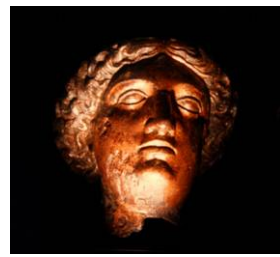
# What was said at last DOE review... (Mont's talk)

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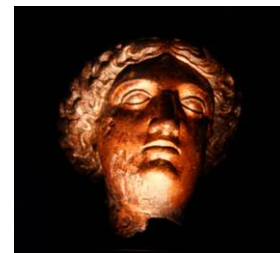
- MINER $\nu$ A
  - NuMI beam
  - Detector in MINOS near hall
  - Low energy neutrino interactions
  - Relevant for long baseline measurements
  - Proposal under consideration

# Where are we now?



- We have become a project...
- Developing prototypes of many components
- Working with Fermilab to understand funding profile and how to get it into the lab budget
- Low Energy Cross Sections: questions still out there!
- Importance to oscillation measurements underscored by APS multidivisional neutrino study report
- MRI Proposal to NSF: under consideration

# The MINERvA Collaboration



D. Drakoulakos, P. Stamoulis, G. Tzanakos, M. Zois  
*University of Athens, Greece*

D. Casper#, J. Dunmore, C. Regis, B. Ziemer  
*University of California, Irvine*

E. Paschos  
*University of Dortmund*

D. Boehnlein, D. A. Harris#, N. Grossman, M. Kostin, J.G. Morfin\*, A. Pla-Dalmau, P. Rubinov, P. Shanahan, P. Spentzouris  
*Fermi National Accelerator Laboratory*

M.E. Christy, W. Hinton, C.E. Keppel  
*Hampton University*

R. Burnstein, O. Kamaev, N. Solomey  
*Illinois Institute of Technology*

S. Kulagin  
*Institute for Nuclear Research, Russia*

I. Niculescu, G. Niculescu  
*James Madison University*

G. Blazey, M.A.C. Cummings, V. Rykalin  
*Northern Illinois University*

W.K. Brooks, A. Bruell, R. Ent, D. Gaskell,  
W. Melnitchouk, S. Wood  
*Jefferson Lab*

S. Boyd, D. Naples, V. Paolone  
*University of Pittsburgh*

A. Bodek, R. Bradford, H. Budd, J. Chvojka,  
P. de Barbaro, S. Manly, K. McFarland\*,  
J. Park, W. Sakumoto, J. Steinman  
*University of Rochester*

R. Gilman, C. Glasshausser, X. Jiang,  
G. Kumbartzki, K. McCormick, R. Ransome#,  
E. Schulte  
*Rutgers University*

A. Chakravorty  
*Saint Xavier University*

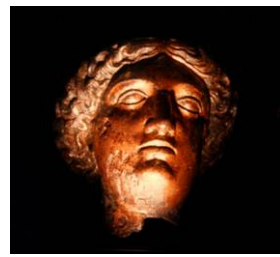
D. Cherdack, H. Gallagher, T. Kafka, W.A. Mann,  
W. Oliver  
*Tufts University*

J.K. Nelson#, F.X. Yumiceva  
*The College of William and Mary*

\* Co-Spokespersons

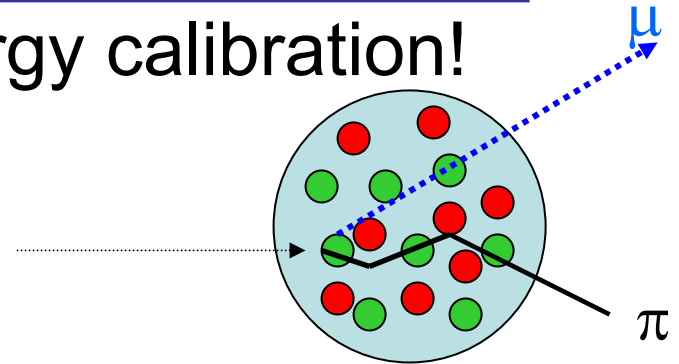
# Members of the MINERvA Executive Committee

# MINERvA and Oscillations



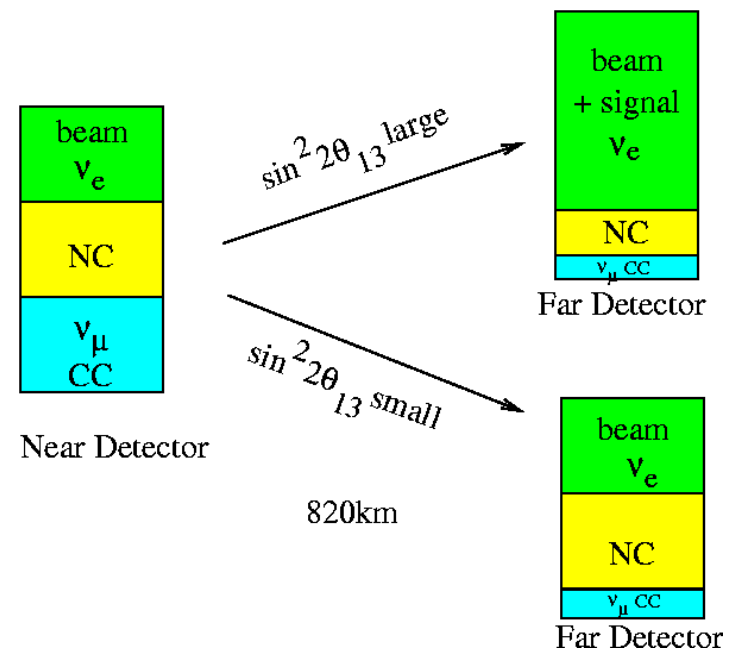
$\Delta m^2$  Measurement: need  $\nu$  energy calibration!

- $\pi$  absorption, rescattering
- final state rest mass

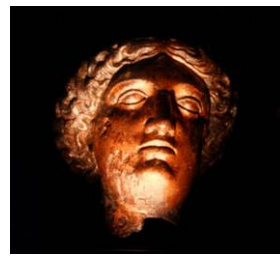


Nuclear Effects Studied in Charged Lepton Scattering, from Deuterium to Lead, at High energies, but  $\nu$  nuclear corrections may be different!

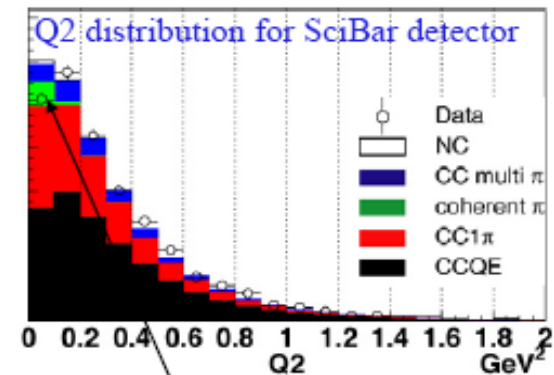
$\nu_e$  appearance  
searches: near and far  
detectors are by  
definition very different!



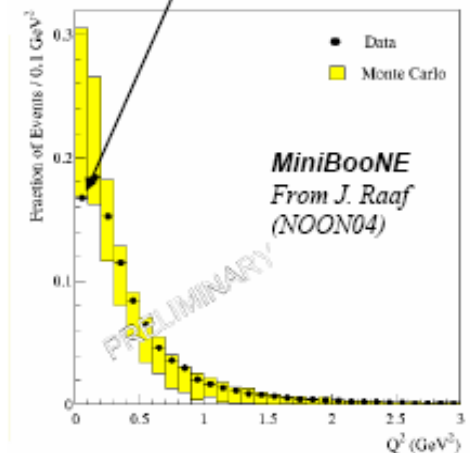
# MINERvA and Cross-Sections



- High  $Q^2$  axial form factor of nucleon (complements high  $Q^2$  vector FF, hot at JLab)
- coherent cross-sections vs. energy (exploit resolution, containing detector)
- differential dists. of exclusive final states (multi-purpose containing detector, high stats)
- A-dependence of:
  - low  $Q^2$  elastic (K2K/MiniBooNE “low  $Q^2$  problem”?)
  - exclusive final states (nuclear re-interactions)
  - deep inelastic scattering ( $F_2^\nu$ ,  $xF_3^\nu$ )

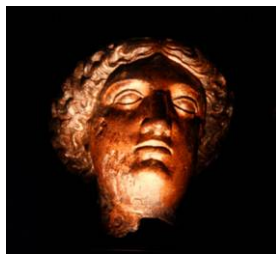


Larger than expected rollover at low  $Q^2$





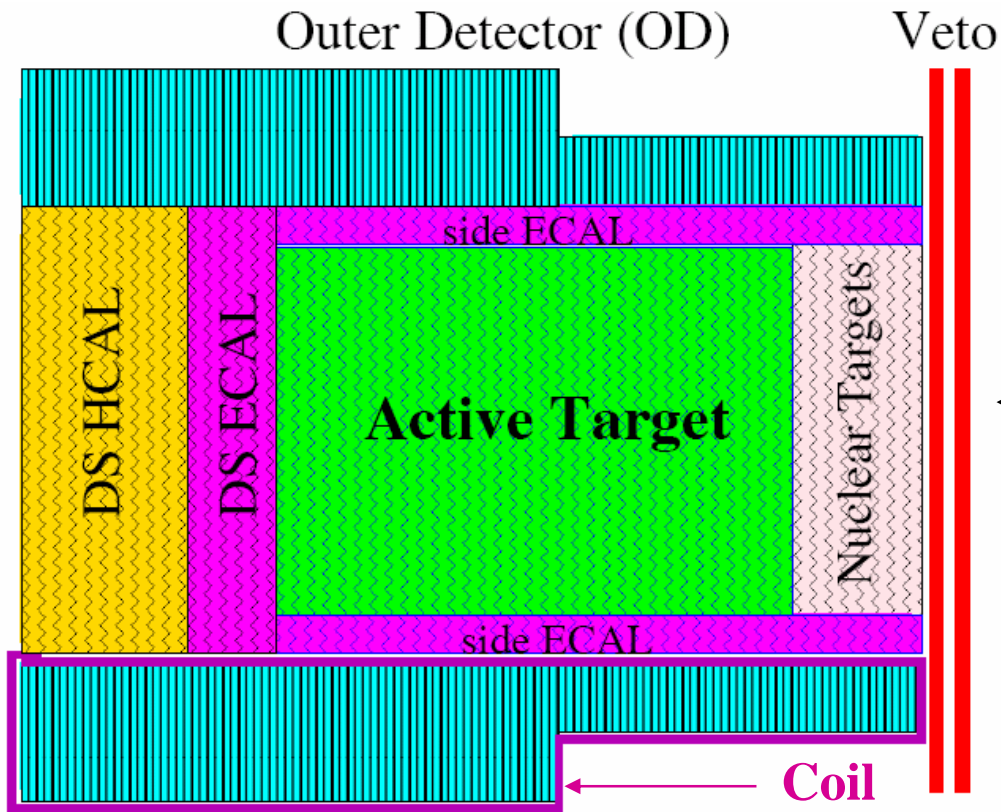
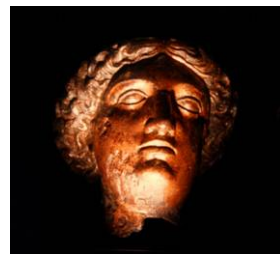
# To Accomplish its Goals...



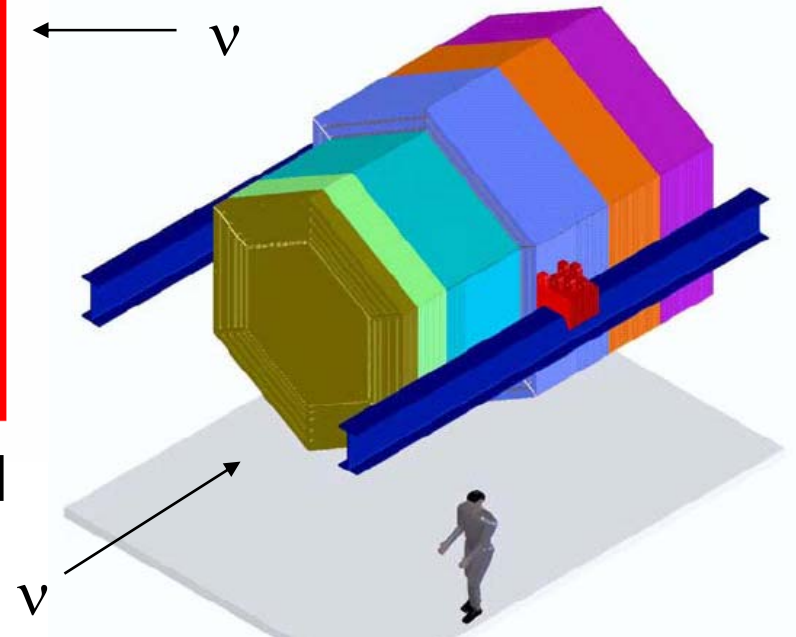
- MINERvA proposes to build a low-risk detector with simple, well-understood technology
- Active core is segmented solid scintillator (K2K SciBar)
  - tracking (including low momentum recoil protons)
  - particle identification
  - few ns timing (track direction, identify stopped  $K^\pm$ )
- Surrounded by electromagnetic and then hadronic calorimeters
  - photon ( $\pi^0$ ) and hadron ( $\pi^\pm$ ) energy measurement
  - magnetized for charge, momentum measurement of escaping muons at wide angles



# Basic Detector Geometry

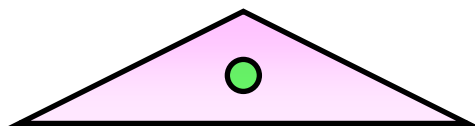
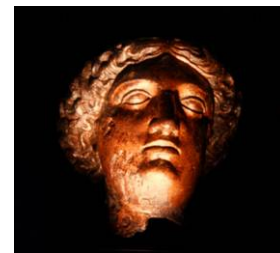


- Active segmented scint. detector 5.87 tons
- ~1 ton of US nuclear target planes (C, Fe, Pb)



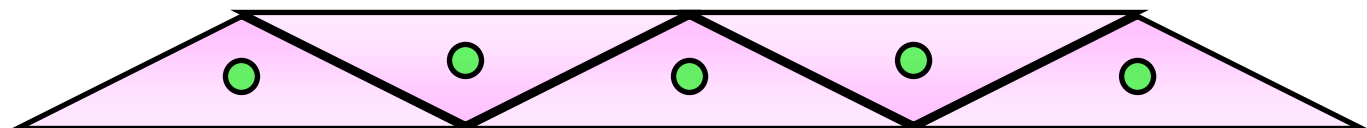
- DS Cals, Nucl. Targets just add absorber to scintillator planes
- Magnetized OD (HCAL) frames

# Extruded Scintillator and Optics

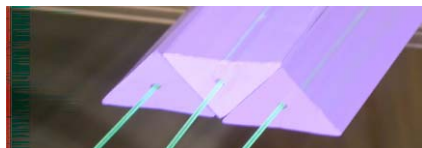


Basic element: 1.7x3.3cm triangular strips.  
1.2mm WLS fiber readout in center hole

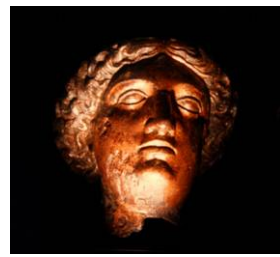
Assemble  
into planes



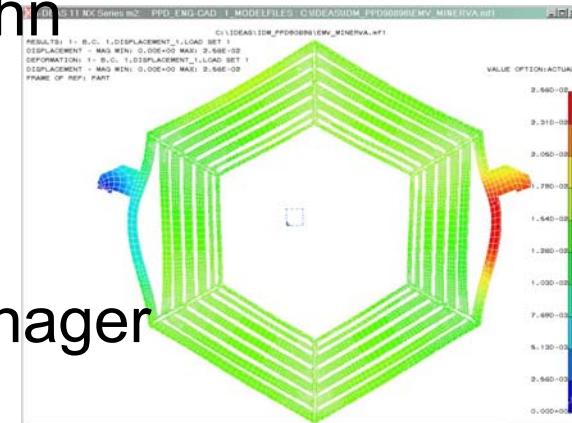
- MINERvA optical system



# Fermilab Responsibilities



- Co-spokesperson: Jorge Morfin
- Project Management:
  - Project Manager: Deborah Harris
  - Co-Deputy PM: Nancy Grossman
  - Document coordinator: Dave Boehnlein
  - Bill Freeman, Suzanne Pacek, project office
- ES&H Oversight and Review: Mike Andrews
- Scintillator Extrusions: Anna Pla, L2 Manager
- Fiber & Connector Polishing: Eileen Hahn
- Electronics Design: Paul Rubinov
- Magnetic Coil: Bob Wands
- Detector Stand: Ernie Villegas
- Installation: Peter Shanahan, co-L2 Manager

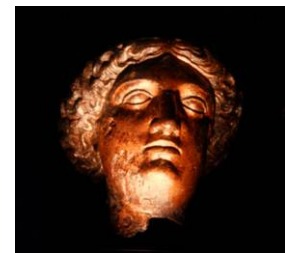


# MINERvA Schedule



- April 2004 – Stage I approval from FNAL PAC
- October 2004 – Complete first Vertical Slice Test with MINERvA extrusions, WLS fiber and Front-End electronics
- January 2005 – First Project Director's ('Temple') Review
- Summer 2005 – Second Vertical Slice Test
- End CY 2005 – Projected Date for MINERvA Project Baseline Review
- October 2006 – Start of Construction
- Summer 2008 – Begin MINERvA Installation and Commissioning in NuMI Near Hall

# MINERvA R&D Progress

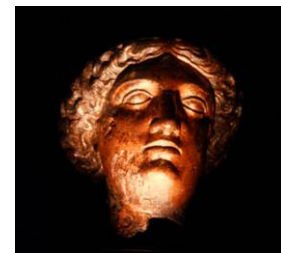


- Completed a vertical slice test (VST1)
  - Inner detector scintillator extrusions
    - FNAL, NIU
  - WLS fibers to PMT Box (MINOS) and similar PMT
    - Rochester, Tufts, FNAL (MINOS)
  - Prototype MINERvA Front-End electronics
    - FNAL, Irvine, Pittsburgh, Rochester
- Mechanical Design “complete” at concept level
  - Rochester, FNAL, Tufts
  - Prototyping cables, steel, PMT box: Tufts, Rutgers, Rochester
- Hit-Level Simulation
  - Irvine, Pittsburgh

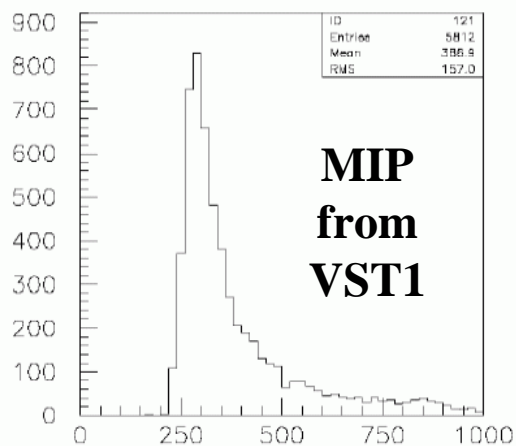
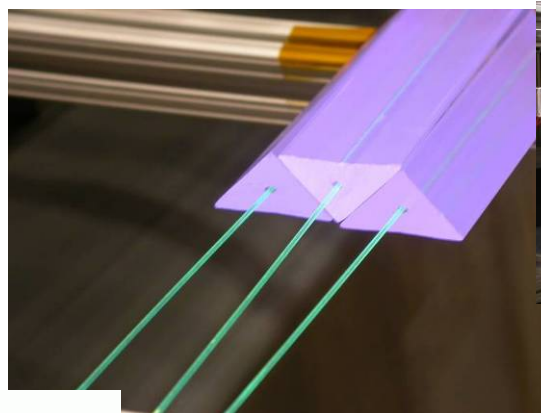
*support for this work from FNAL-PPD,  
DOE HEP university funds, and funds  
from collaborating universities*



# Vertical Slice Test (VST1)

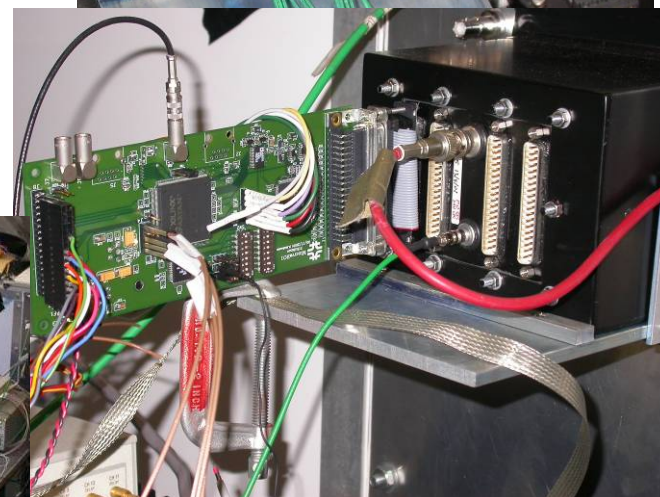


VST1 array,  
electronics  
and DAQ

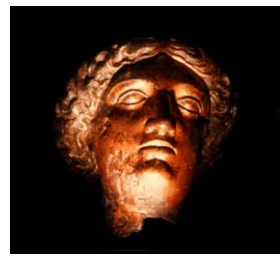


8 PE/MIP per  
doublet

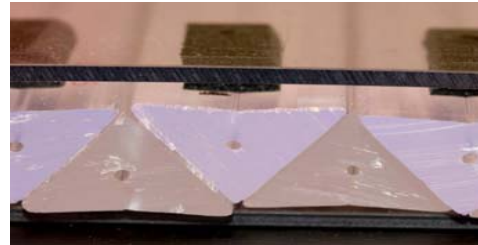
25 May 2005



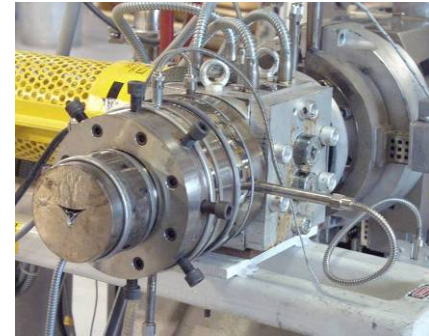
# Current Prototyping



- Refining scint. extrusion



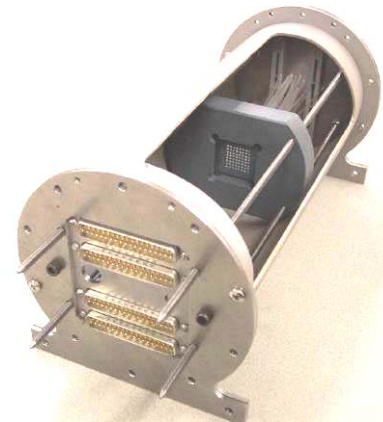
- First “trapezoid” of OD steel



- Prototype PMT box



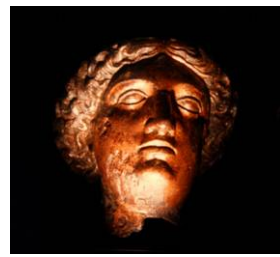
- Prototype clear fiber cables in progress



- 2<sup>nd</sup> Prototype front-end and prototype readout electronics



# Remaining FY05 R&D Plans

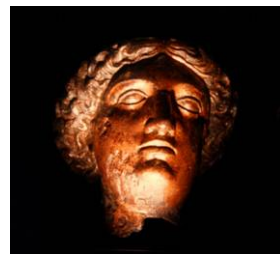


- Co-extruder purchase and installation (63k\$)
  - Get best estimate for light levels and tracking resolution
- Fibers and Scintillator consumables (79k\$)
- Connector Prototyping and light-tightness measurements (65k\$)
- Begin scintillator plane assembly R&D (51k\$)
  - Get long bars of triangular extrusions
  - Fiber routing, gluing, etc. (extra 58k\$ for fibers)
- PMT Box Factory Setup (38k\$)
- Electronics Design Work, to be used in PMT testing
- Detector Stand, Connectors (7k\$), Magnetics, Installation design

**Total M&S for FY05 R&D: 300k\$**

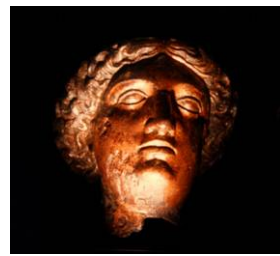


# FY06 R&D Plans



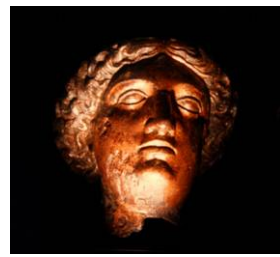
- PMT Testing Facilities (JMU, Athens)—are we ready to make bulk purchase?
- Plane Assembly (HU, W&M): build Half Plane Prototype to test module scanning procedure
- PMT Boxes: make enough to do PMT tests (Tufts, Rutgers)
- Continue Design Work
  - Electronics (FNAL)
  - Frame, Coil (FNAL, Rochester)
  - Outer Detector (Rochester)
  - Installation Procedure (FNAL)
- Scintillator extrusions: make enough for half plane prototype, work on Outer Detector die
- Fiber and Connector Prototyping (FNAL, Rochester)

# Status of MINERvA Project



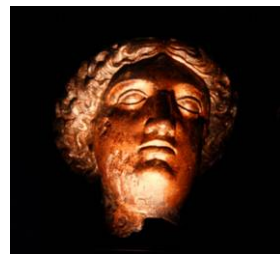
- Detailed costing and schedule model
  - basis for our design report and DOE/NSF proposals
- First FNAL director's ("Temple") review 1/05
  - generally positive report... they were impressed with our level of detail in design, cost, safety, etc.
  - recommended: formal project management plan, cost vs. physics optimization studies, development of more detailed resource-loaded cost and schedule model
- Current Negotiations with Lab:
  - Effort to level the funding profile
  - "What would happen if we brought a University-based factory to FNAL"

# Project Management



- Experiment has proposed and Fermilab directorate approved
  - Project Manager: Deborah Harris
  - Two co-Deputy Project Managers
    - Ron Ransome overseeing University efforts
    - Nancy Grossman overseeing Fermilab efforts
- Project Management Plan has been drafted by the executive committee
- Plan has had first reading by Ed Temple and Dean Hoffer, iterating with Project Manager and co-Deputy Project Managers

# MINERvA Costs



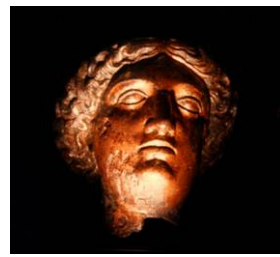
- Costs (in k\$) as best we know them now (including ~40% contingency, **no FNAL G&A**)
- will revisit in detail before baselining
- R&D only in FY05-06, Mostly Construction Funds in FY07-08

	FY'05	FY'06	FY'07	FY'08	
Fermilab Labor	190	449	576	282	
Fermilab M&S	7	0	200	526	
Funds to University	297	876	3022	2880	
<b>Total</b>	<b>494</b>	<b>1325</b>	<b>3798</b>	<b>3689</b>	<b>9305</b>

**NSF MRI still pending: 2M\$ total, 500k R&D, for Funds to Univ.**

Red: already approved by FNAL

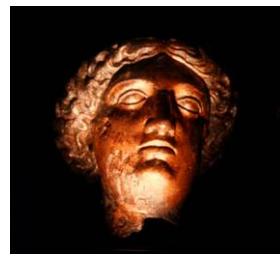
# MINERvA...



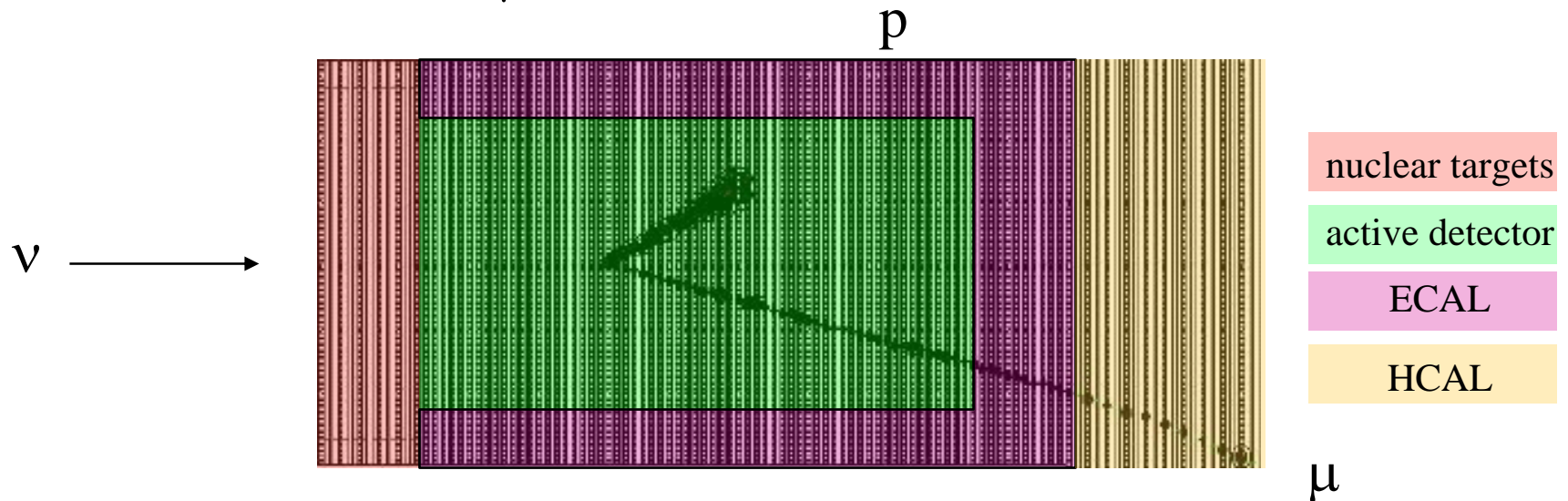
- Opportunity for unique and critical FNAL role in world neutrino efforts in a modest-scale project
  - construction funds in FY07 means running in FY09
  - only possible because of investment in NuMI
- On track technically to build and use detector
  - R&D and prototyping progressing
- FNAL folks play important roles in several different parts of the experiment!

backup slides

# Example Events

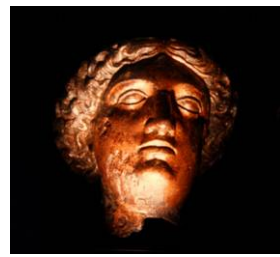


- Quasi-elastic  $\nu_\mu n \rightarrow \mu^- p$

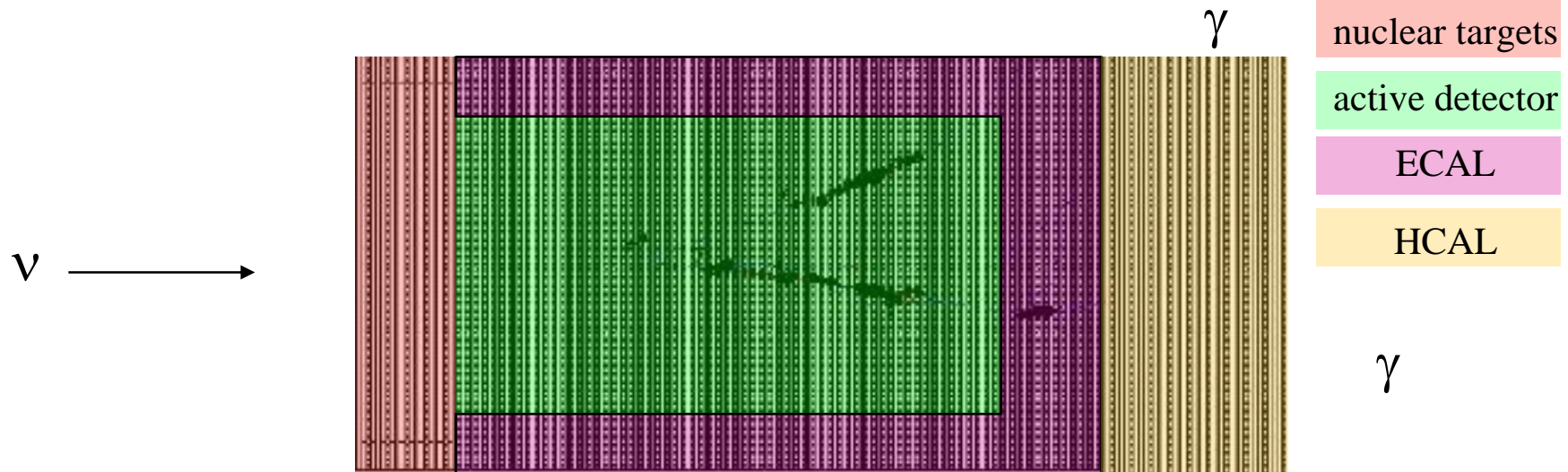


- proton and muon tracks are clearly resolved
- observed energy deposit is shown as size of hit; can clearly see larger proton  $dE/dx$
- precise determination of vertex and measurement of  $Q^2$  from tracking

# Example Events (cont'd)



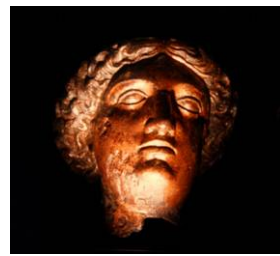
- $\pi^0$  Production



- two photons clearly resolved (tracked). can find vertex.
- some photons shower in ID,  
some in side ECAL (Pb absorber) region
- photon energy resolution is  $\sim 6\%/\sqrt{E}$  (average)



# MINERvA statistics and running



Assume  $9 \times 10^{20}$  POT:  $7.0 \times 10^{20}$  in LE  $\nu$  beam,  $1.2 \times 10^{20}$  in sME  $\nu$  beam and  $0.8 \times 10^{20}$  in sHE  $\nu$  beam

$\nu_\mu$ Event Rates per fiducial ton		
Process	CC	NC
Quasi-elastic	103 K	42 K
Resonance	196 K	70 K
Transition	210 K	65 K
DIS	420 K	125 K
Coherent	8.4 K	4.2 K
<b>TOTAL</b>	<b>940 K</b>	<b>305 K</b>

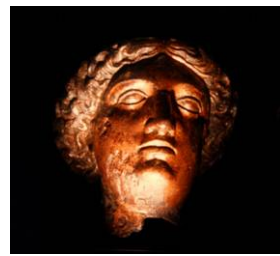
**Typical Fiducial Volume =**  
**3-5 tons CH, 0.6 ton C,  $\approx$  1 ton Fe**  
**and  $\approx$  1 ton Pb**

**3 - 4.5 M events in CH**  
**0.5 M events in C**  
**1 M events in Fe**  
**1 M events in Pb**

## Main Physics Topics with Expected Produced Statistics

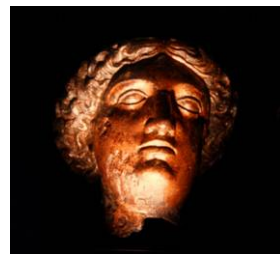
- **Quasi-elastic** -  $\nu + n \rightarrow \mu^- + p$  - 300 K events off 3 tons CH
- **Resonance Production** - e.g.  $\nu + N \rightarrow \nu / \mu^- + \Delta$  600 K total, 450K  $1\pi$
- **Coherent Pion Production** -  $\nu + A \rightarrow \nu / \mu^- + A + \pi$ , 25 K CC / 12.5 K NC
- **Nuclear Effects** - C: 0.6M events, Fe: 1M and Pb: 1 M
- **$\sigma_T$  and Structure Functions** - 2.8 M total / 1.2 M DIS events
- **Strange and Charm Particle Production** - ( $> 60$  K **fully** reconstructed)

# Vital Statistics of MINERvA



Number of Channels	30992
Channels in ID+CALS	25088
Channels in OD	5904
Volume of Scintillator (m <sup>3</sup> )	22.5
WLS Fiber (km)	90.7
Clear Fiber (km)	41.6
Number of M-64 PMTs	503
Mass of ID (metric tons)	10.8
Mass of OD in ID region (metric tons)	98.0
Mass of CALS, Nuclear Targets (metric tons)	27.2
Mass of OD in CAL region (metric tons)	62.9
Total MINERvA Mass (metric tons)	199
Plastic Region Mass (metric tons)	5.87
Data Rate (bits/spill)	7.9E+6

# A Brief History of MINERvA



- December 2002 - Two EOs for neutrino scattering experiments using the NuMI beam and similar detector concepts presented to the PAC. PAC suggests uniting efforts and preparing proposal.
- December 2003 - MINERvA proposal presented to PAC. PAC requests more quantitative physics studies and details of MINERvA's impact on Fermilab.
- January 2004 - Submit proposal for MRI funding support (maximum \$2M) of partial detector to NSF. Rejected due to no guarantee for funding rest of detector.
- March 2004 - MINERvA Impact Statement submitted to Directorate and presented to an Impact Review Committee.
- April 2004 - Proposal addendum containing additional physics studies and report from the Impact Review Committee presented to PAC. Receive Stage I approval.
- Summer 2004 - R&D Program concentrating on front-end electronics, scintillator extrusions and a "vertical slice test"
- October 2004 - Proposal to NP and EPP of NSF to fund bulk of MINERvA.
- December 2004 - Proposal to NP and HEP of DOE to fund bulk of MINERvA.
- January 2005 - First Director's Review of MINERvA
- February 2005 – With release of FY06 budget, DOE of budget process crystallizes; decision that MINERvA must be primarily funded by FNAL budget.